University of Technology, Sydney

Faculty of Engineering & Information Technology

Finite Element Analysis of Fluid-Structure Interaction in Piping Systems

A thesis submitted for the degree of

Master of Engineering (Research)

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CERTIFICATE OF ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate

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ABSTRACT

As a typical fluid-structure interaction (FSI) system, the fluid-filled pipe widely used in industry is investigated in this thesis. It is concerned with two kinds of coupled vibration analysis, in the case of a fluid-filled pipe rigidly bonded to a steel-frame structure at a number of fixed points. One is the fluid-structure interaction analysis in the fluid-filled pipe system while the other is the structural coupling analysis between the pipe and the steel support. Considering the pipe and the steel support as two subsystems, due to the existence of these bonding points, the vibration of one subsystem will force the other to create a new particular vibration pattern. Thus a finite element approach is presented to combine the dynamic models of two subsystems to obtain the natural frequencies and mode shapes of the whole system.

The discretised finite element equation describing the free vibration of the system is deduced in a displacement-pressure format. In order to process both unsymmetrical mass and stiffness matrices due to the FSI coupling, an iterative numerical method is applied to solve the generalized eigenvalue problem and therefore the natural frequencies and model shapes of the coupled system could be obtained. In order to save computation time for modal analysis, the number of degrees of freedom of the full model is significantly reduced by employing dynamic condensation method.

Numerical examples are given to verify the feasibility of the calculation method. The obtained computational natural frequencies are compared with those obtained from experiment. Different parameters influencing the coupled vibration are discussed as well and these results could provide theoretical foundation for the optimization design

of structure-fluid coupled systems such as hydraulically interconnected suspensions fluid-filled pipe systems for vehicle braking, etc.